Using Fish Community-Based Measures of Stream Health to Develop Nutrient Criteria for Virginia Streams and Rivers

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(Academic Advisory Committee of DEQ)

Statement of the Problem

Develop statistically-valid, objective nutrient criteria based on definitions of stream health that incorporate living resources and related uses

Proof-of-Concept *re:* nutrient criteria in non-wadeable streams, based on fish community metrics (e.g. IBI)

Objectives

- Assemble a single, geo-referenced database combining stream nutrient concentrations, nutrient loadings, and fish community metrics
- Evaluate patterns among the parameters and metrics; do statistically valid relationships exist?
- Recommendations *re*: developing numeric nutrient criteria from data, if patterns exist

Pilot Study Approach

- Identify existing data sources
- Focus the analysis (parameters/regions)
- Integrate relevant data
- Combine data by geospatial units (HUCs)
  - a ‘one-to-many’ relationship for each 6th-order HUC
- Exploratory (graphical) analyses
  - multiple comparisons among parameters and regions
- Recommendations for ‘next steps’

Major Data Sources

1. DEQ Ambient Monitoring Program

   -600K records from Roger Stewart

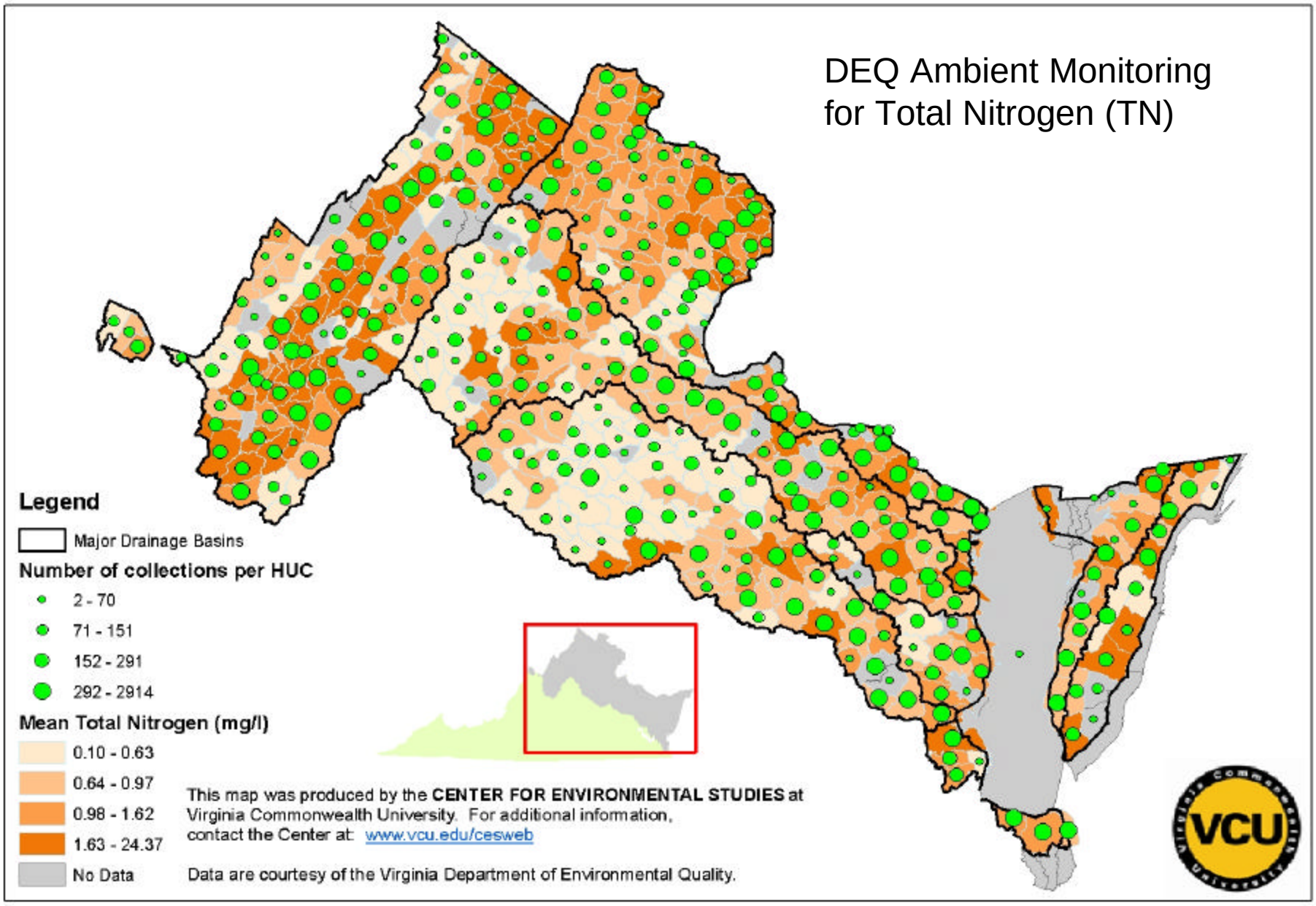
   -Nutrient concentrations (TN, TP only)

   -Chlorophyll-*a* concentrations**

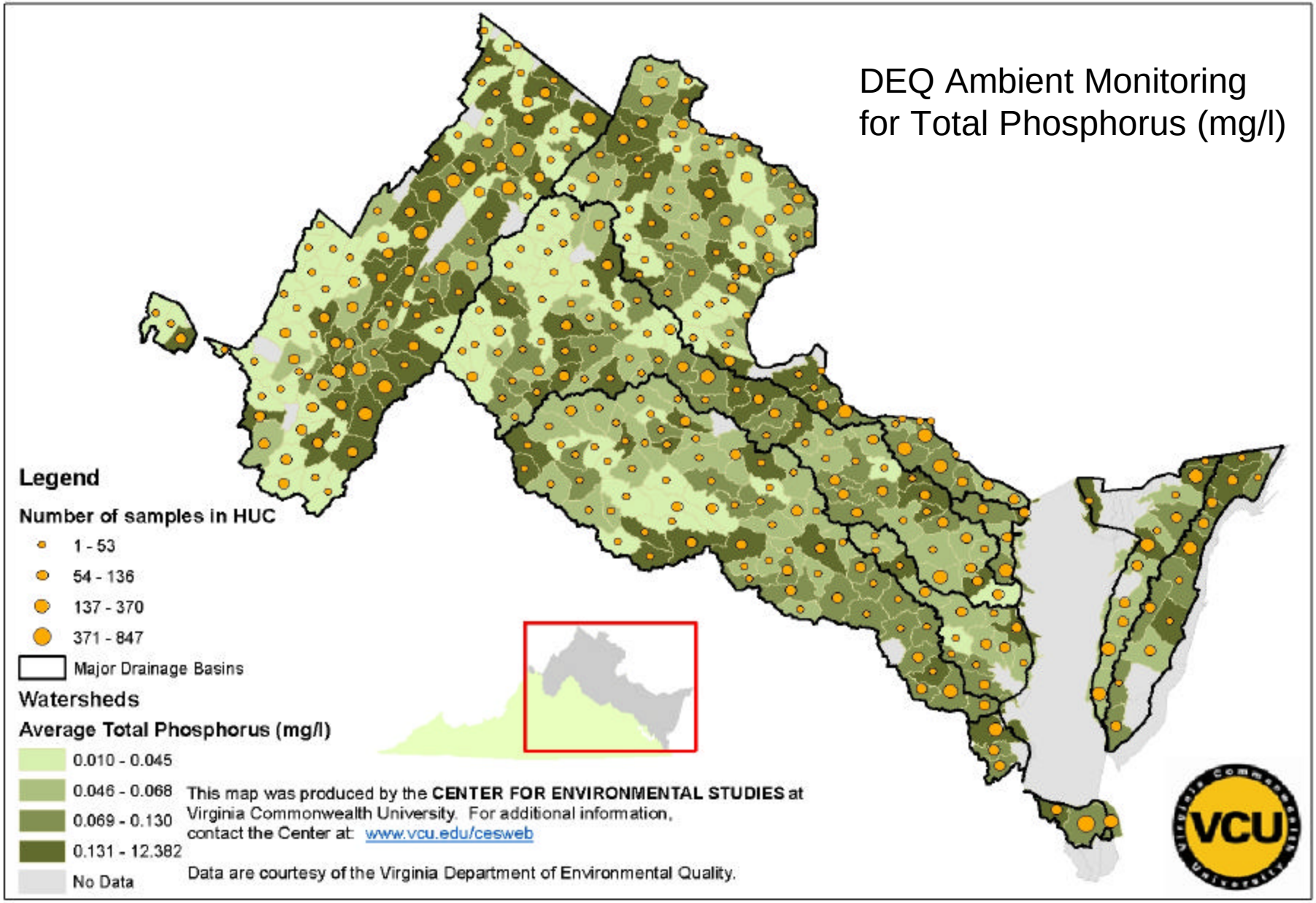
   -Chesapeake Bay Watershed (*excluding* the James), Coastal Zone, Eastern Shore, Shenandoah basin

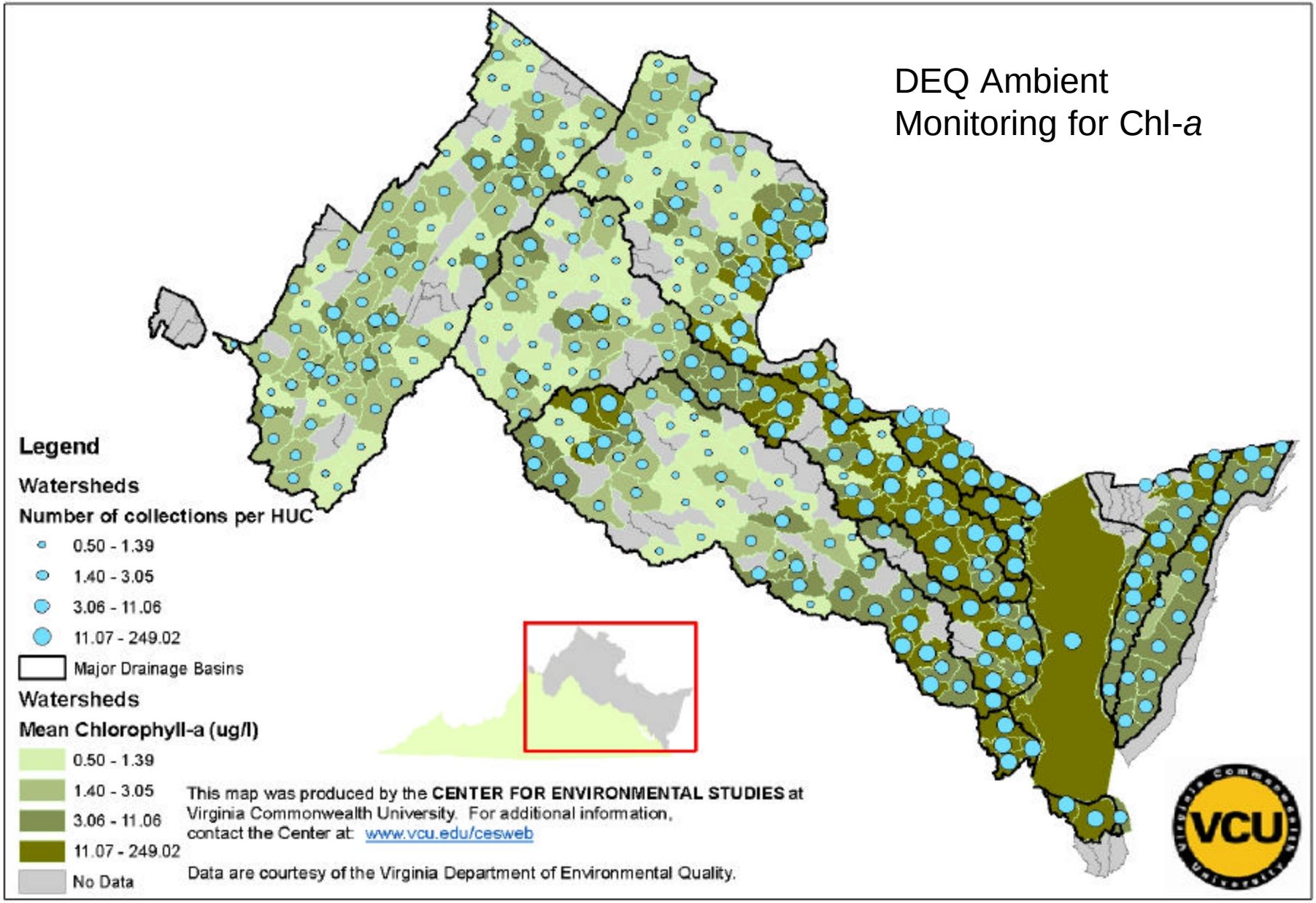
   -Freshwater streams & rivers only

DEQ Ambient Monitoring for Total Nitrogen (TN)



DEQ Ambient Monitoring for Total Phosphorus (mg/l)




DEQ Ambient Monitoring for Chl-*a*
Legend
Watersheds
Number of collections per HUC
0.50 - 1.39
1.40 - 3.05
3.06 - 11.06
11.07 - 249.02
Major Drainage Basins
Watersheds
Mean Chlorophyll-a (ug/l)
0.50 - 1.39
1.40 - 3.05
3.06 - 11.06
11.07 - 249.02
No Data
This map was produced by the CENTER FOR ENVIRONMENTAL STUDIES at Virginia Commonwealth University. For additional information, contact the Center at: www.vcu.edu/cesweb
Data are courtesy of the Virginia Department of Environmental Quality.
VCU

Major Data Sources

1. DEQ Ambient Monitoring Program
   - 600K records from Roger Stewart
   - Nutrient concentrations (TN, TP only)
   - Chlorophyll-a concentrations**
   - Chesapeake Bay Basin, exclusive of the James
2. DCR NPS Nutrient Loadings
   - Karl Huber, 2006 NPS Assessment
   - TN & TP; edge-of-stream model outputs
3. VCU's INSTAR program
   - fish community/ecological models; infer stream health

INSTAR at a glance

The Database

Aquatic resources and in-stream habitat information

>200K records representing >1,925 stream reaches (probabilistic design)

Ecological models (i.e., *virtual* reference streams) to support objective assessment and analysis of stream health

The Application

Interactive and internet based (ArcIMS; MS SQL)

High-resolution spatial data (GIS) coverages

Wide range of functions and database queries supported; new '*lite*' interface in beta testing

Accessible to anyone with a PC and modem

http://instar.vcu.edu

INSTAR Supports Two Bioassessment Protocols:

Modified Index of Biotic Integrity (mIBI)

Metrics:

1. Native species richness
2. Number of R, T, & E species
3. Number of non-indigenous species
4. Number of 'critical' species
5. Number of tolerant species
6. Number of intolerant species

Regional Scoring Criteria
Ranges between 6-30
Broad geospatial scales (HUCs)

Virtual Stream Assessment (VSA)

Percent comparability to *virtual* regional reference conditions

Empirical range: 8-92% of region-appropriate VSA model

Statistics currently support several regional VSA models, including lower piedmont, coastal zone and Shenandoah basin

Intermediate spatial scales (reaches)

Quantitative data are inputs

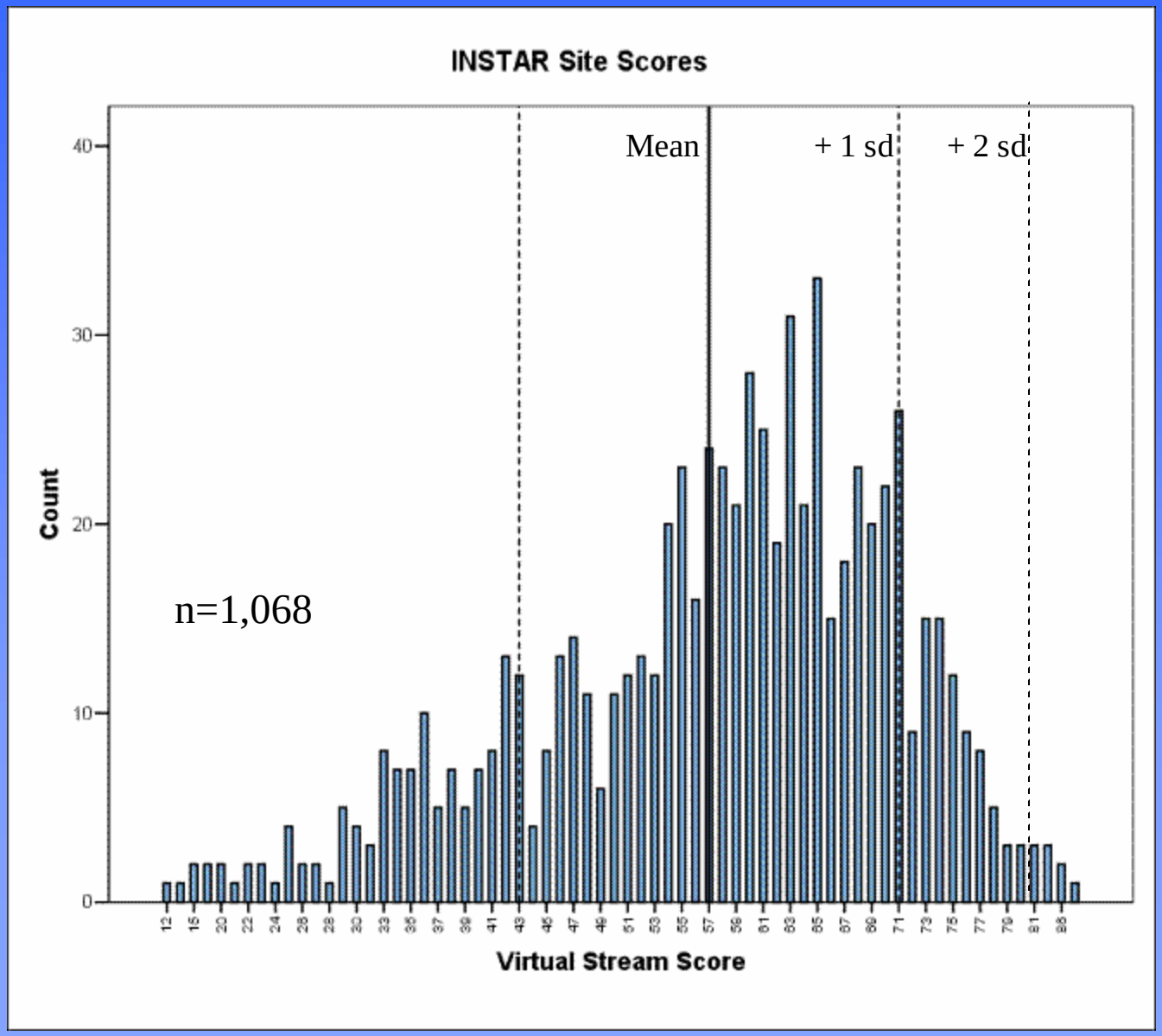
Virtual Stream Model—Lower Coastal Plain

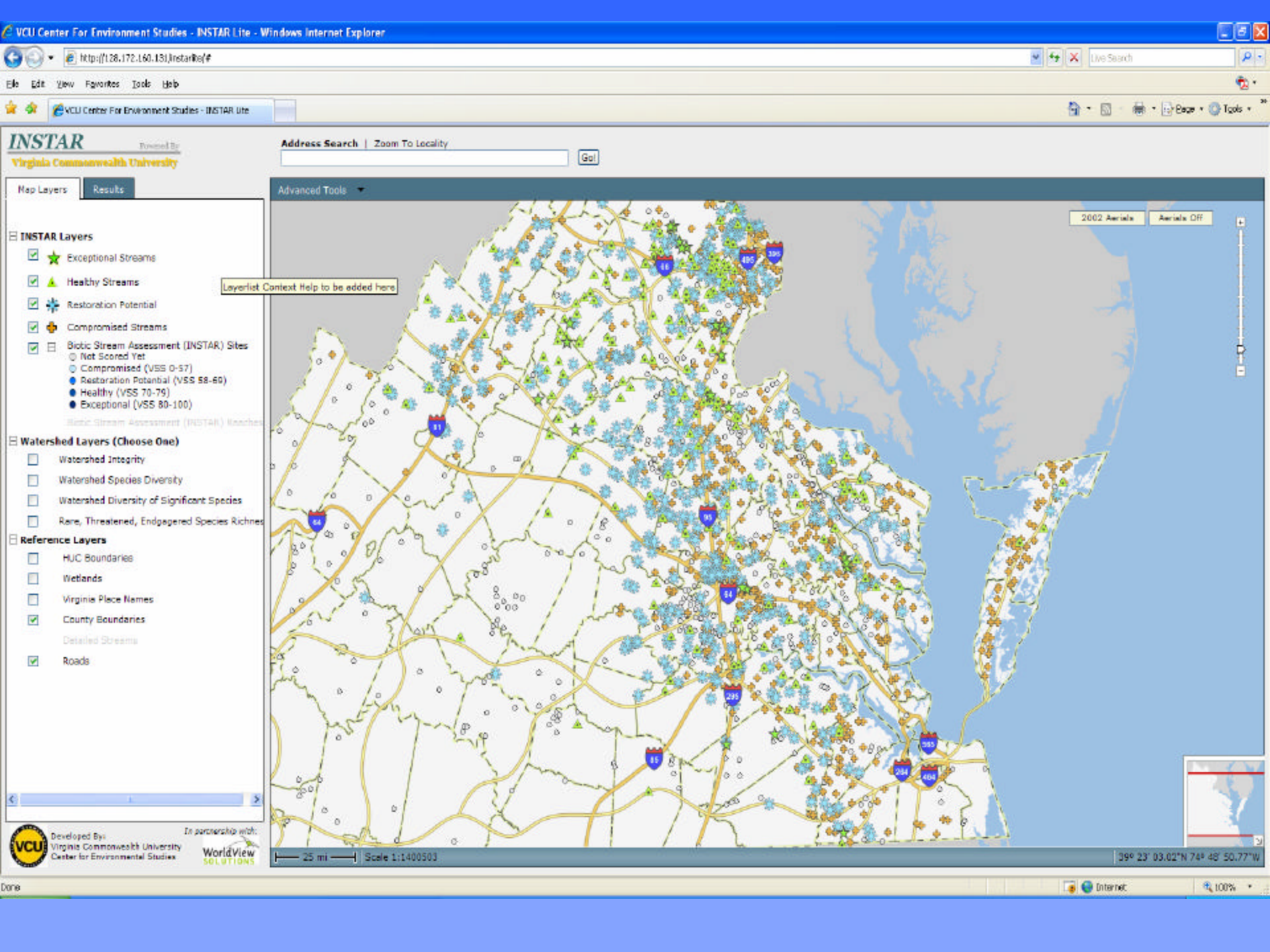
Virtual Reference Stream (100%) = 0.05(*EP*) + 0.02(*Rich*) - 0.19(*Chnlalt*) - 0.1(*Intol*) + 0.18(*Toler*) - 0.05(*HBI*) + 5.67

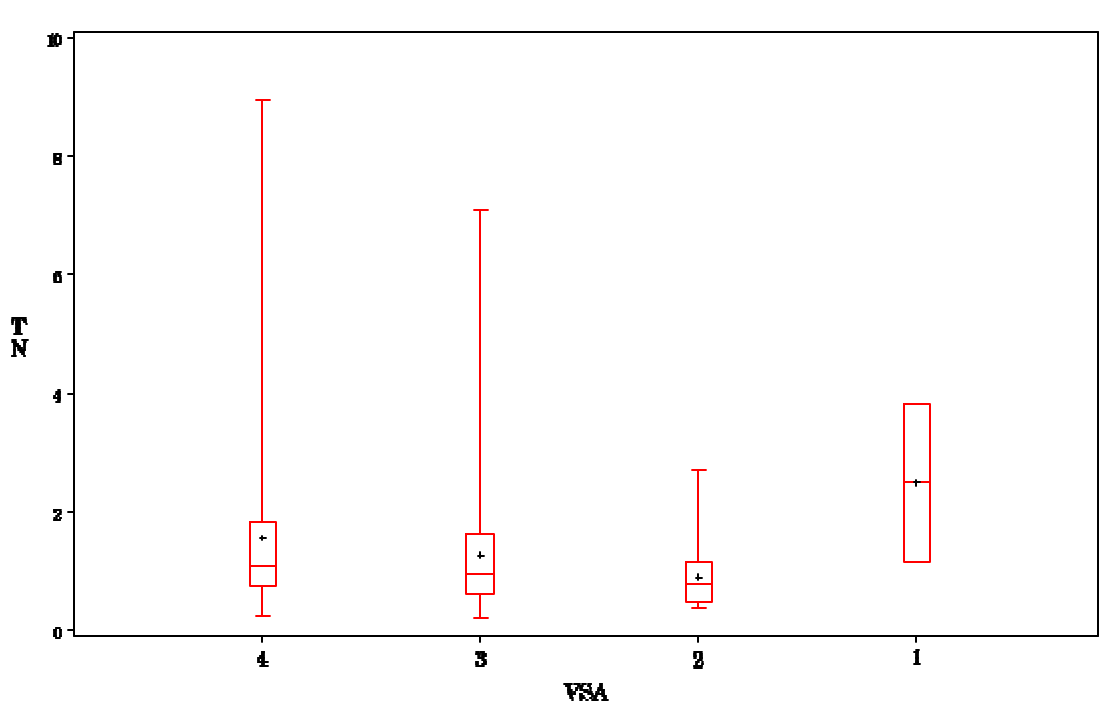
EP = Ephemeroptera & Plecoptera taxa
Rich = fish species richness (native)
Chnalt = percent channel alteration
Intol = percent intolerant species
Toler = number tolerant species
HBI = Hilsenhoff Biotic Index

adjusted R square = 0.72

Stream Ecological Integrity Classes

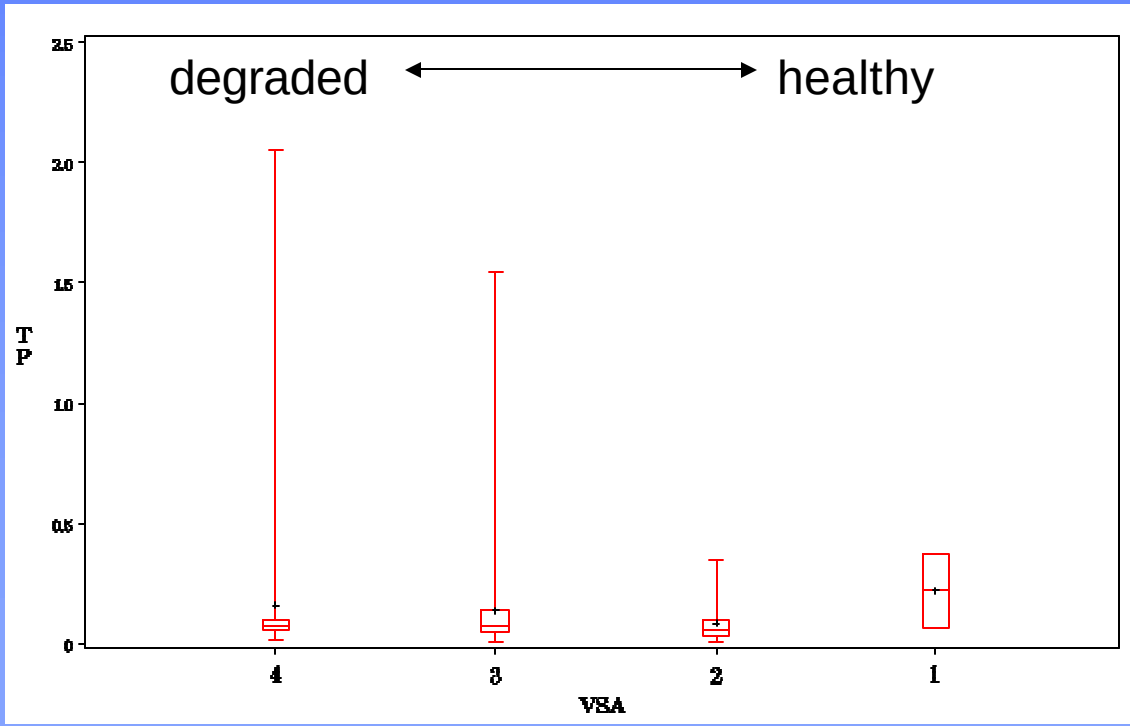


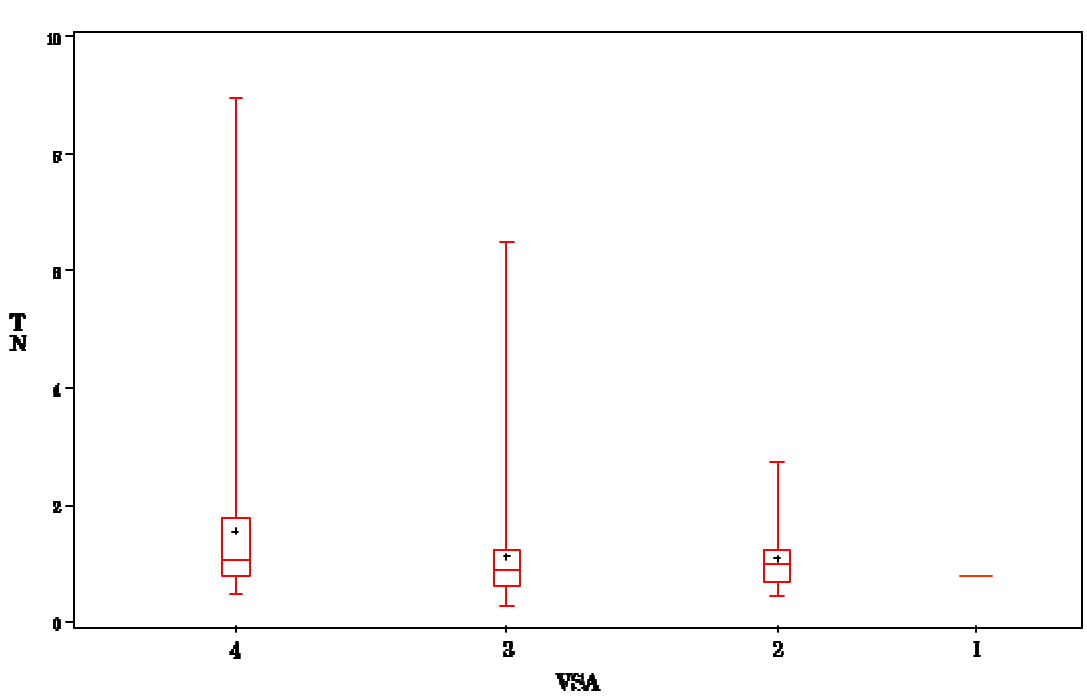

VCU Center For Environment Studies - INSTAR Lite - Windows Internet Explorer
INSTAR
Virginia Commonwealth University
Address Search | Zoom To Locality
Go!
Map Layers
Results
Advanced Tools
INSTAR Layers
Exceptional Streams
Healthy Streams
Restoration Potential
Compromised Streams
Biotic Stream Assessment (INSTAR) Sites
Not Scored Yet
Compromised (VSS 0-57)
Restoration Potential (VSS 58-69)
Healthy (VSS 70-79)
Exceptional (VSS 80-100)
Layerlist Context Help to be added here
Watershed Layers (Choose One)
Watershed Integrity
Watershed Species Diversity
Watershed Diversity of Significant Species
Rare, Threatened, Endangered Species Richnes
Reference Layers
HUC Boundaries
Wetlands
Virginia Place Names
County Boundaries
Roads
2002 Aerials
Aerials Off
Developed By:
Virginia Commonwealth University
Center for Environmental Studies
In partnership with:
WorldView SOLUTIONS
25 mi
Scale 1:1400503
39° 23' 03.02"N 74° 48' 50.77"W
Done
Internet
100%



Ambient nutrient concentrations *vs*. Stream Health (VSA score)

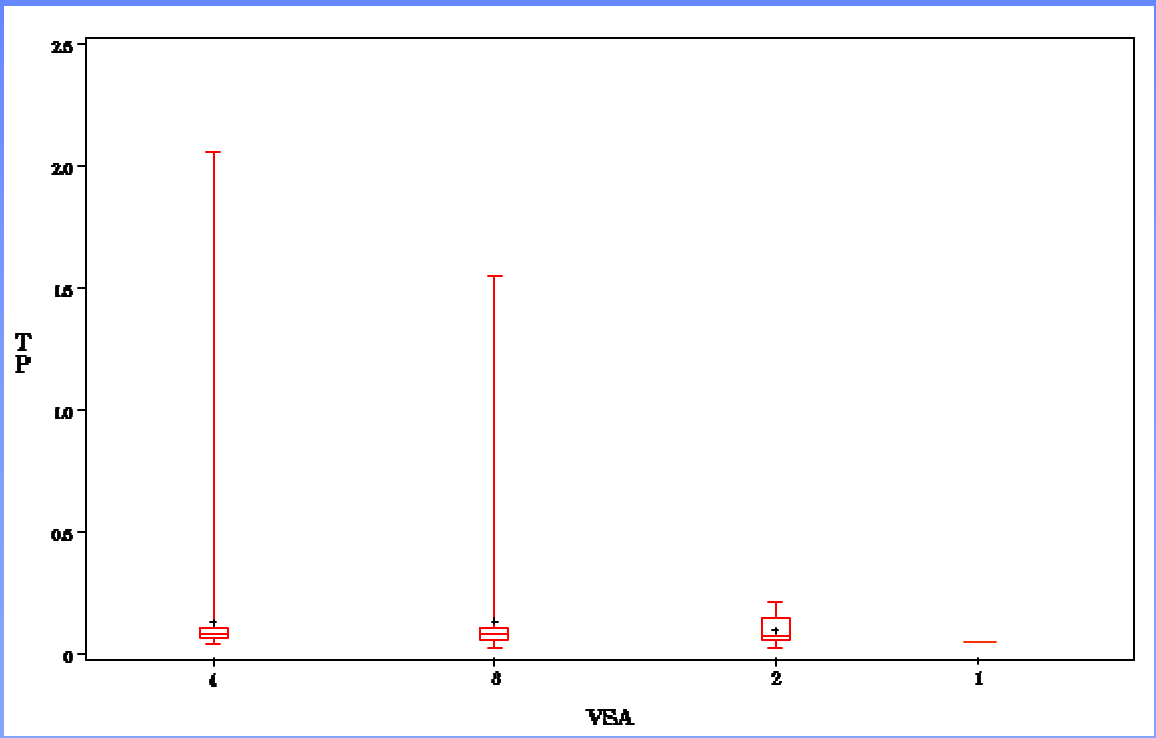
Ches. Bay region

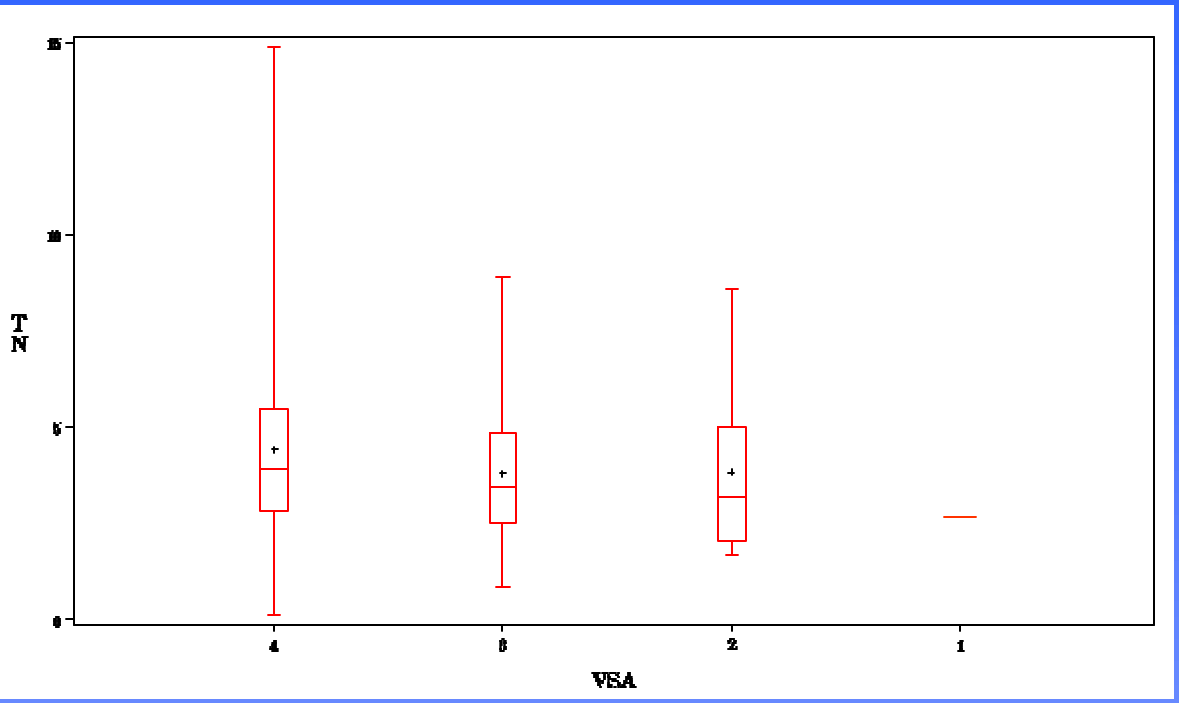




Ambient nutrient concentrations *vs*. Stream Health (VSA score)

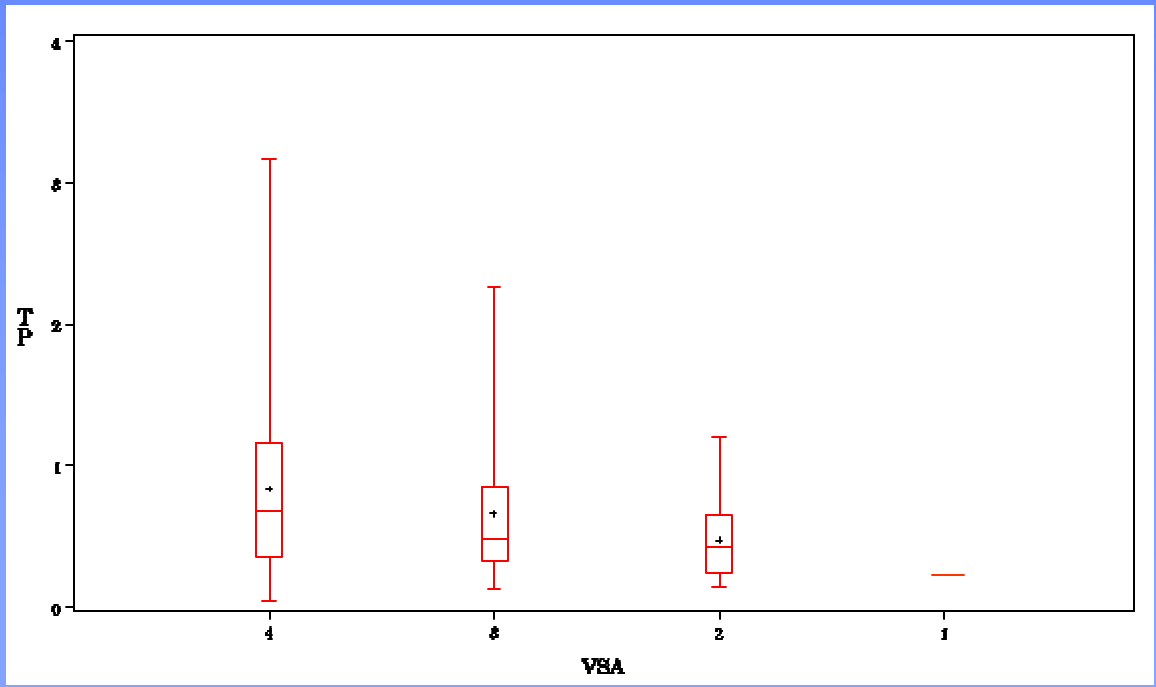
CZ region

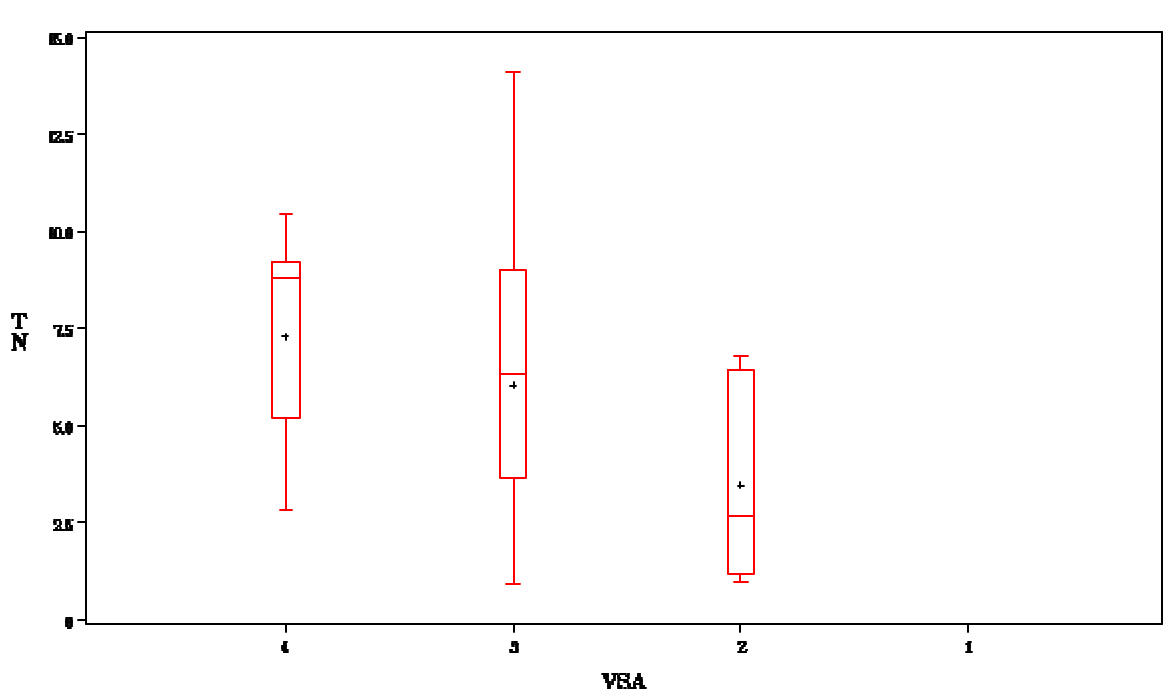




NPS Nutrient Loadings vs. Stream Health (VSA score)

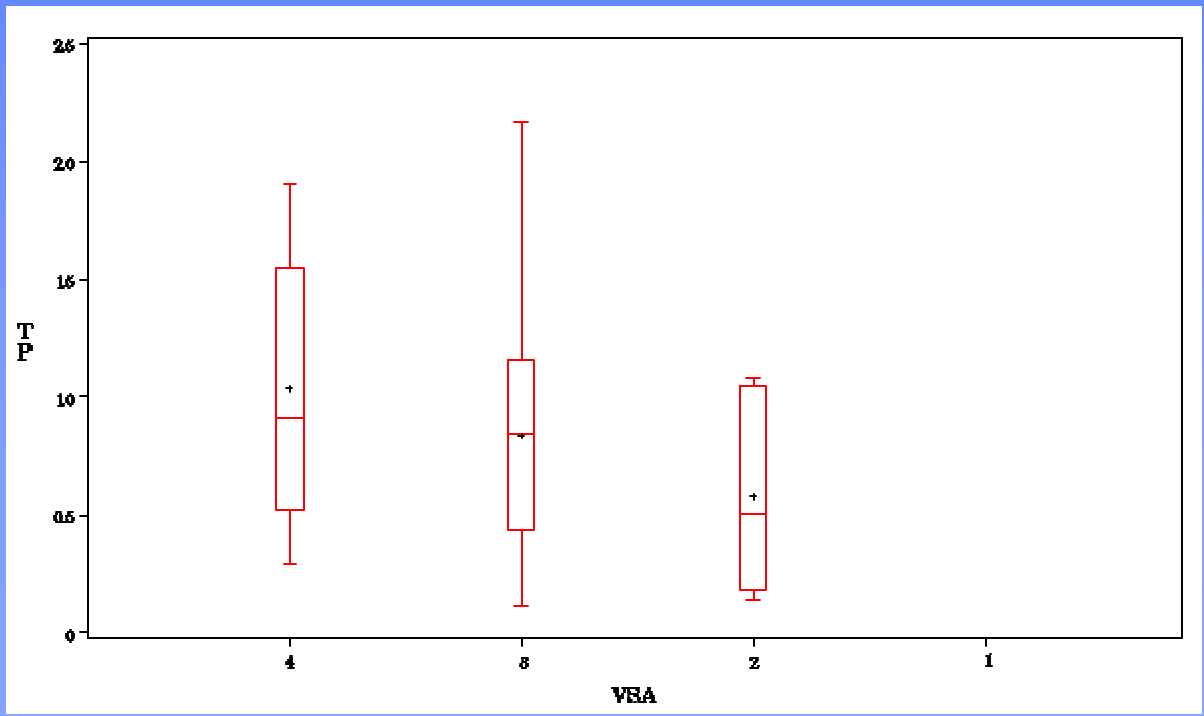
CZ region

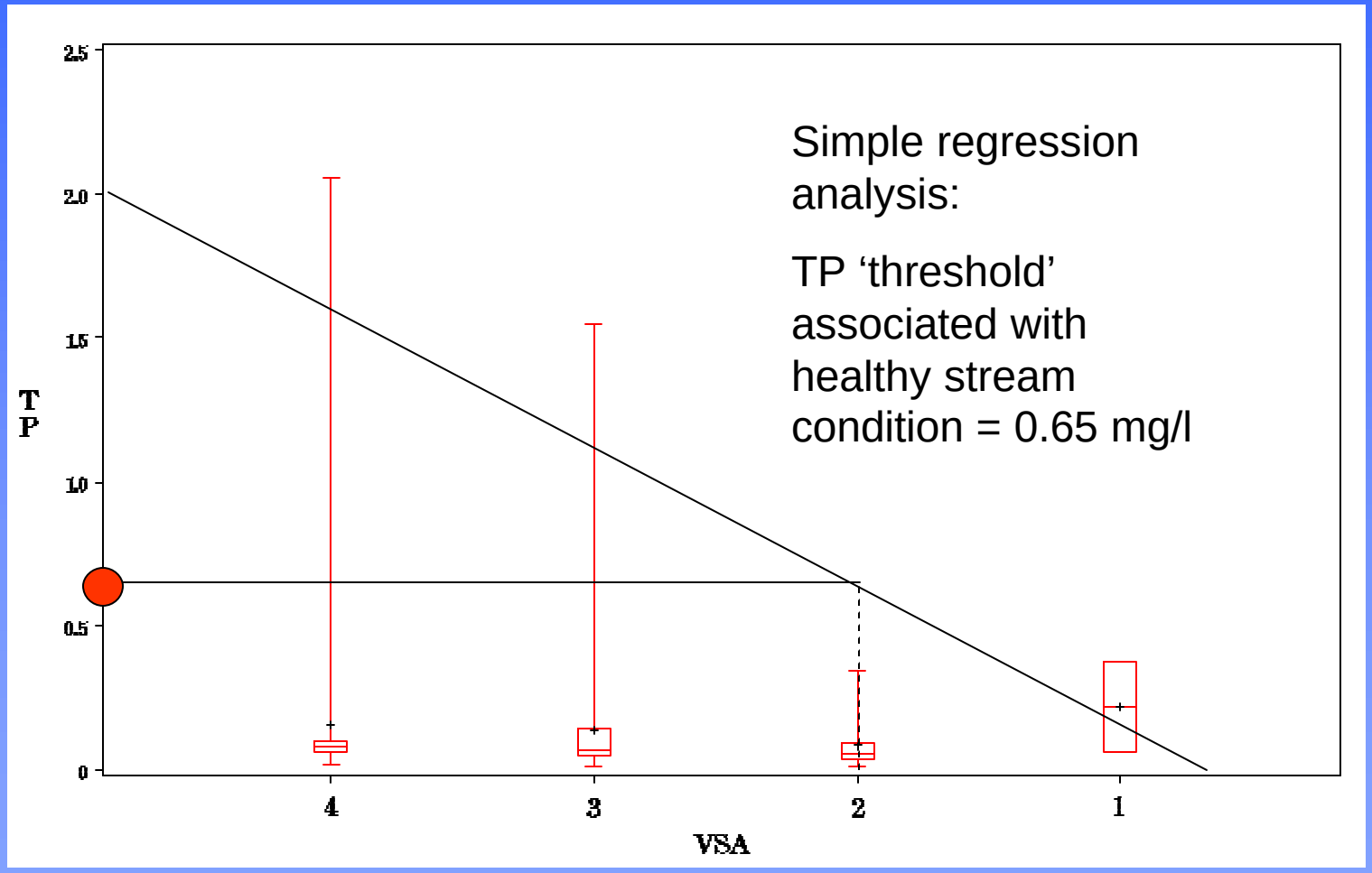




NPS Nutrient Loadings vs. Stream Health (VSA score)

Shenandoah basin




2.5
2.0
1.5
1.0
0.5
0
TP
4
3
2
1
VSA
Simple regression analysis:
TP ‘threshold’ associated with healthy stream condition = 0.65 mg/l

Findings

- Significant negative relationship among stream health (fish metrics) *vs*. [nutrients] or loadings; Chl-*a* is different
- Pattern consistent among regions and basins; similar to limited literature
- Many limitations, however, with current data and analyses
- Demonstrates proof-of-concept for using fish community data to establish criteria?

Next Steps

- Focus on *non-wadeable* streams and rivers; expand geographic coverage
- Operational definition of ‘non-wadeable’
- Leverage DEQ’s ProbMon program to develop a synoptic dataset for the entire state (’06-’08)
- More rigorous statistical analyses; build more VSA fish community models for other regions
- What are the underlying mechanisms of fish community ‘response’ to [nutrients]?
- Criteria development; conditional probability approach
- Validation of draft criteria